ISOLATION OF LACUSTRINE BASINS AND MARINE REGRESSION IN THE KUUJUJUAQ AREA, NORTHERN QUÉBEC, AS INFERRED FROM DIATOM ANALYSIS

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ABSTRACT The Holocene sediment records of two lakes, located 50 km south of the Ungava Bay coast near Kuujujaq have been examined using diatom analysis in order to trace basin isolation from marine influence. The succession of diatom zones clearly documents paleoenvironmental changes induced by glacio-isostatic uplift and regression of postglacial D’Iberville Sea through consecutive periods of marine occupation, isolation from the sea and subsequent lacustrine conditions. Diatom analysis proved to be an effective tool in identifying the position of the isolation contact in the sediment columns and in defining the related changes in palaeosalinity and isolation dynamics. Based on the 14C-dated isolation contacts and the threshold elevations of both lakes, a tentative emergence curve has been reconstructed which is in agreement with curves from adjacent areas. This allowed, for the first time, to infer trends in glacio-isostatic rebound and duration of marine submergence for an area from which palaeogeographical data are almost entirely lacking. The curve shows that, following deglaciation about 7000 years ago, the Kuujujaq area experienced continuous and rapid emergence in the order of 5.7-5.8 m/century until 4800-4300 years BP. Thereafter, emergence slowed to a rate of approximately 0.9 m/century. This study provides further evidence for the usefulness of diatom analysis in reconstructing sea-level changes and land uplift of formerly glaciated regions.

RÉSUMÉ L’isolement de deux bassins lacustres et la régression marine dans la région de Kuujujaq, reconstitués à l’aide de l’analyse des diatomées. Le contenu diatomifère de carottes provenant du fond de deux lacs situés près de Kuujujaq à 50 km au sud du rivage de la baie d’Ungava, a été examiné en vue de retracer les phases d’isolement de ces lacs de la mer postglaciaire d’Iberville. La succession stratigraphique des zones de diatomées démontre clairement les changements paléoenvironnementaux provoqués par le relèvement isostatique postglaciaire et la régression marine; on reconnaît en effet dans les séquences diatomologiques une phase d’occupation marine, une phase d’isolement de la mer et une phase lacustre subséquente. L’analyse des diatomées s’est révélée un outil utile pour identifier la phase et les modalités d’isolement des bassins devenus lacustres et pour retracer les changements de paléosalinités associés. En tenant compte des dates au 14C sur les unités d’isolement, de l’altitude du seuil des lacs et de la forme des courbes d’émergence des régions adjacentes, une courbe d’émergence préliminaire de la région de Kuujujaq a pu être construite. Cette courbe montre qu’après la déglaciation, datée à 7000 BP, l’émergence fut rapide et continue à un taux moyen de l’ordre de 5,7-5,8 m/ siècle jusqu’à environ 4800-4300 BP. Par après, l’émergence fut plus lente, à un taux d’environ 0,9 m/ siècle. Cette étude s’ajoute à d’autres pour mettre en évidence le grand potentiel de l’analyse des diatomées pour la reconstruction précise de courbes de variation du niveau marin et de relèvement isostatique des régions englacées.


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** Guy Lortie passed away August 2, 1988. His death was the result of a tragic accident within the context of a scientific expedition in northern Québec.

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INTRODUCTION

The late-glacial and postglacial history of extensive parts of the territory south of Ungava Bay still remains unstudied. According to Lauriol and Gray (1987), this area became deglaciated only after 7000 BP. Southwest of the bay, the ice masses lingered until about 6500 BP. Recent data reveal that deglaciation within the coastal areas was followed by immediate inundation from the postglacial D'Iberville Sea about 7400 to 7200 BP (Allard et al., 1989). The D'Iberville Sea occupied the bay and the surrounding inland areas (Fig. 1), including major river valleys, such as that of the Koksoak River (Gray and Lauriol, 1985; Dyke and Prest, 1987; Lauriol and Gray, 1987).

In the Kuujjuaq (Fort Chimo) area, the deglaciation pattern, its chronology, and the resulting sea-level changes are still poorly known. The only available information has been obtained mainly by air photo interpretation and identification of glacio-marine deltas and washed till zones (Lauriol, 1982). Near the mouth of Koksoak River, the marine limit of D'Iberville Sea reaches elevations of 150-155 m above sea-level (asl) (Lauriol, 1982). Gangloff et al. (1976) believe it to be situated at 183 m asl near Kuujjuaq. The two lakes investigated in this study, Hendry Lake and Tasilaq-sud Lake, are located 50 km south of Ungava Bay and are at elevations below this Holocene marine limit (Figs. 1 and 2).

Comprehensive studies on postglacial diatom histories have not previously been carried out in northern Québec and our knowledge of the diatom flora is limited to qualitative analysis of only a few samples from southeastern Ungava Bay (Lortie in Mathieu, 1984). The existing and more extensive palynological studies are restricted to the Ungava peninsula west of the bay (Richard, 1981) and to the Québec-Labrador peninsula in the east (e.g. McAndrews and Samson, 1977; Short and Nichols, 1977; Short, 1976; Lamb, 1980, 1985; Stravers, 1981). A major investigation of lake sediments and mires is that of Richard (1981), which describes the different stages of postglacial vegetation history southwest of the Ungava Bay. However, the region in question belongs to those many areas in northern Québec from which modern pollen and diatom analyses are still lacking.

Diatoms (class Bacillariophyceae) represent a valuable source of biological proxy data for paleoenvironmental reconstructions. They have proven to be especially useful in defining shore displacement and sea-level fluctuations in coastal localities since they are very sensitive to changes in salinity, tidal currents, water depth, trophic conditions and pH (e.g. Alhonen, 1971; Florin, 1977; Stabell, 1980, 1985; Kjærnerud, 1981, 1986; Lie et al., 1983; Haggart, 1986; Björck and Digerfeldt, 1986; Vos and de Wolf, 1988). Radiometric dating of marine to lacustrine transitions, preserved in cores from coastal basins, has been frequently used for establishing chronologies of relative sea-level change and isostatic uplift (e.g. Kaland et al., 1984; Björck and Digerfeldt, 1986; Retelle et al., 1989).

In the present study, diatom analysis has been used in order to add new paleoecological and paleogeographical data by tracing and dating the isostatic isolation of two emerged coastal lakes from marine influence; thus, special emphasis is placed in this paper on variations in diatom assemblage composition in connection with the marine to lacustrine transition. A more detailed analysis of floristic changes, spanning the entire lacustrine sequences of both lakes, is provided by Plenitz (1989).

PHYSIOGRAPHIC SETTING OF THE TWO LAKES

Hendry Lake (58°07'N, 68°14'W) and Tasilaq-sud Lake (unofficial name; 58°14'N, 68°27'W) are located on opposite sides of the Koksoak River, near Kuujjuaq, at altitudes of 40 and 45 m, respectively (Fig. 2). Local bedrock consists mainly of granite-gneisses belonging to the Churchill Geological Pro-

![Figure 1](image1.png)

**FIGURE 1.** Location of lakes Hendry and Tasilaq-sud.

**Localisation des lacs Hendry et Tasilaq-sud.**

![Figure 2](image2.png)

**FIGURE 2.** General distribution of Quaternary deposits (dark) and bedrock outcrops (light) in the study area. Simplified from Delisle et al., 1986.

**Distribution générale des dépôts quaternaires (foncé) et des affleurements rocheux (pâle) dans la région étudiée. Simplifiée de Delisle et al., 1986.**
vience of the Canadian Shield. Both lakes lie within the George Plateau physiographic region (Bostock, 1970), where sparsely vegetated upland plateaus with thin soils are dissected by structural depressions and valleys.

Surveys of glacial flow patterns along the Ungava Bay coast have revealed a converging flow of the Late Quaternary Laurentide Ice Sheet masses towards the Ungava Bay depression (Gangloff et al., 1976; Lauriol, 1982). Intersecting glacial striae in the vicinity of Kujujuak suggest that a dominant northerly, Late Wisconsinan ice movement was superimposed on an earlier northeasterly flow into Ungava Bay (Gray and Lauriol, 1985).

The widespread and discontinuous mantle of surface deposits covering the bedrock is mainly of glacial origin and can be attributed to the last Wisconsinan Glaciation. Subsequent incursion by the D’Iberville Sea (Delisle et al., 1986) has intensively reworked and modified the distribution of these surficial deposits. The most extensive sediment accumulations occur within the more vegetated lowlands (Fig. 2).

Tasiliac-sud Lake is a small (0.35 km²) elongated basin located about 15 km northwest of Kujujuak. It lies within a narrow structural depression extending in a south-north direction towards Ungava Bay. To the east and the west, it is surrounded by the higher terrain of bordering uplands, with mean elevations ranging between 75 and 155 m asl. A prominent sill consisting of a 400 m long beach ridge at 45 m asl surrounds the northern and eastern margins of this lake; this ridge has served as an isolation threshold. Hendry Lake, with a surface area of 7.35 km², is situated 10 km east of Kujujuak on a plateau that separates the two important estuaries of the Kokoak and False rivers (at this site also called Lac Kohlmeister). While the southern half of the lake is contained within rocky hills, the northern end has very low shores on flat, boggy land that slopes very gently towards the actual estuary of False River. The most important morphometric features of both lakes are summarized in Table I.

In the Ungava Bay area, the very large tidal range (12.9 m maximum amplitude at the mouth of Kokoak River; Canada, 1990) is responsible for the presence of wide intertidal zones over rock platforms and mudflats (Lauriol and Gray, 1980). Air photo interpretation revealed that intertidal flats formerly extended within the surroundings of both lakes (Plenitz, 1989).

The present-day subarctic climate of the region is characterized by long winters, short summers, and by a mean annual temperature of −5.2°C. The mean annual precipitation is 476 mm of which about 40% falls in the form of snow. The frost-free season lasts about 60 days. Both lakes are ice-covered for a very long period; freeze-up and break-up generally occur in early November and late June respectively (Québec, 1984).

Phytoecologically, the Kujujuak region lies within the shrub subzone of the forest-tundra zone (Payette, 1983). This transitional zone extends between the forest-tundra and the tundra, and is dominated by a shrubby vegetation composed principally of dwarf birch (Betula glandulosa) and green alder (Alnus crispa), with isolated stands of coniferous trees (Picea mariana, Larix laricina).

### MATERIAL AND METHODS

Sampling was carried out in May 1987 through 1.5 m of ice, using a modified Livingstone piston corer (internal diameter = 5 cm) and a casing of plastic drainpipe. Sediment cores were taken from the deepest part through 7 m and 4 m of water in lakes Hendry and Tasiliac-sud, respectively. Consecutive core sections were recovered by repeated drives through the same cased hole.

The cores taken from Tasiliac-sud Lake provided an undisturbed sedimentary sequence measuring 3.85 m in total length, including sediments deposited during basin isolation from the sea and the following period of lacustrine sedimentation. In the 1.25 m long core recovered from Hendry Lake, which presents a longer marine but considerably shorter lacustrine sequence, radiocarbon dates seem to reveal the absence of sediments spanning the period from 1440 BP until present. Since loss of sediment can be excluded, other factors such as contamination with “old” carbon, very low sedimentation rates, or both most likely account for this lack of recent record. Similar anomalies have been observed in lakes with extremely low sedimentation rates during the late Holocene (e.g., Short and Nichols, 1977; Diaz et al., 1989; Retelle et al., 1989), which caused surface sediments to be of considerable age rather than strictly modern. The considerable difference in core length, however, is most likely due to

<table>
<thead>
<tr>
<th>Table I</th>
<th>Summary of morphometric and topographic data for lakes Hendry and Tasiliac-sud.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hendry Lake:</td>
<td></td>
</tr>
<tr>
<td>Depth (m)</td>
<td>7</td>
</tr>
<tr>
<td>Surface area (km²)</td>
<td>7.35</td>
</tr>
<tr>
<td>Total length of shoreline (km)</td>
<td>20.75</td>
</tr>
<tr>
<td>Maximum length (km)</td>
<td>5.56</td>
</tr>
<tr>
<td>Maximum width (km)</td>
<td>1.34</td>
</tr>
<tr>
<td>Drainage basin area (km²)</td>
<td>45.8</td>
</tr>
<tr>
<td>Ratio lake surface area: drainage basin area</td>
<td>0.16</td>
</tr>
<tr>
<td>Elevation above sea-level (m)</td>
<td>40</td>
</tr>
<tr>
<td>Elevation of surrounding relief (m)</td>
<td>75-105</td>
</tr>
<tr>
<td>Distance from Ungava Bay (km)</td>
<td>43</td>
</tr>
<tr>
<td>Aerial photograph series A 11425/129-132</td>
<td></td>
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<tr>
<td>A 11444/88-91</td>
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<tr>
<td>A 12087/115-121</td>
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</tr>
</tbody>
</table>

| Tasiliac-sud Lake: | |
| Depth (m) | 4 |
| Surface area (km²) | 0.35 |
| Total length of shoreline (km) | 4.2 |
| Maximum length (km) | 1.77 |
| Maximum width (km) | 0.30 |
| Drainage basin area (km²) | 9.7 |
| Ratio lake surface area: drainage basin area | 0.036 |
| Elevation above sea-level (m) | 45 |
| Elevation of surrounding relief (m) | 75-155 |
| Distance from Ungava Bay (km) | 38 |
| Aerial photograph series A 11444/139-141 | |
the significantly different sedimentary processes prevailing in
the two basins.

The cores were extruded in the Laboratoire de paléocôlo-
logie at Université Laval, surface cleaned, subsampled and
then wrapped in plastic and aluminum foil for storage in a dark
room at 4°C.

The seven radiocarbon dates obtained are listed in Table
II. They are reported as uncorrected radiocarbon years before
present (BP). The outer part of the 5 cm long core sections
selected for radiocarbon dating was removed in order to
eliminate possible contamination by smearing during coring or
extrusion. Standard acid and basic sample pretreatments
were followed by benzene syntheses which were given four
times the normal counting time in order to minimize statistical
errors.

The radiocarbon dates from the isolation contacts only
yield minimum ages since the samples were taken from the
lacustrine side of the contact. This was done in order to avoid
potential errors caused by the "reservoir age effect" of sea
waters (Mangerud and Gulliksen, 1975; Hillaire-Marcel, 1979;
Kalant et al., 1984). Also, one must keep in mind that the
samples cover a distinct time interval. The magnitude of this
latter error depends on the sedimentation rates, as well as on
the thickness of the samples used for dating.

Particle-size analysis of the inorganic fraction of the sedi-
ments was carried out in order to help detect changes in the
sedimentary environment. The samples were described using
the textural classification system outlined in the glossary of
earth science terms (Agriculture Canada, 1976).

Loss-on-ignition, commonly used as a measure of the
organic matter content of a sediment, was determined by
drying the samples for 24 hours at 65°C and subsequent
combustion at 550°C for 2 hours.

Samples for diatom analysis (1 cm²) were taken from the
cores at intervals of 5 or 10 cm. All samples were first treated
with hydrogen peroxide (30%H₂O₂), in order to bleach and
destroy the organic matter, and then repeatedly rinsed to
neutrality. Microsphere markers were added to the solution in
order to facilitate quantitative assessment of diatom abun-
dance according to the method of Battarbee and Kneen
(1982). A 0.5 ml aliquot was transferred to a 22×22 mm cover
slip and allowed to dry overnight. Permanent mounts were
then prepared using Naphrax, a medium with a high refractory
index (dn = 1.73).

For each sample 500 to 1000 valves were counted and
identified on a Zeiss I II Photomicroscope under oil immersion
at 500X and 1250X magnifications. In the lowermost section
of the Hendsky Lake core, however, the very poor preservation
of diatoms did not allow for quantitative analysis of the sample
material. Analysis was complemented by observations on a
JEOL-2511S scanning electron microscope. Identifications
were made with reference to the works of Bérard-Therriault et
al. (1986, 1987), Cardinal et al. (1984, 1988), Cleve-Euler
(1964), Hustedt (1930-1966), Krammer and Lange-Bertalot
Patrick and Reimer (1966, 1975), Patrick and Freeese (1961,

The results of diatom analysis have been synthesized in
the form of percentage diagrams (Figs. 3 and 4). Within these
diagrams, the biostratigraphic zones are defined by the domi-
nant species (>10%), and diatoms are classified according to
the Halobian system defined by Kolbe (1927), which sub-
sequently has been modified by Hustedt in 1957 (Table III).

RESULTS

Sediment stratigraphy/Core description

Both lakes contain a sequence of marine sediments over-
lain by lacustrine sediments (Figs. 3 and 4). The two units are
separated by a more or less distinctive isolation contact that
marks the isostatic emergence of the basins from the postglacial
D'Iberville Sea (Pienitz and Lortie, 1988).

HENDRY LAKE

The sediment sequence consists of three main units
(Fig. 3). From base to top these are:

<table>
<thead>
<tr>
<th>TABLE II</th>
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<tbody>
<tr>
<td>Sample number</td>
</tr>
<tr>
<td>HEN-III</td>
</tr>
<tr>
<td>HEN-III</td>
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<tr>
<td>HEN-III</td>
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<tr>
<td>HEN-IV</td>
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<tr>
<td>TAS-I</td>
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<tr>
<td>TAS-II</td>
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<tr>
<td>TAS-III</td>
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</tbody>
</table>

* situated at the transition with the basal inorganic sediments

<table>
<thead>
<tr>
<th>TABLE III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification of diatoms according to their salinity tolerance (Hustedt 1957)</td>
</tr>
<tr>
<td>1. Polyhalobous taxa: marine taxa with an optimum range of 30% and more</td>
</tr>
<tr>
<td>2. Mesohalobous taxa:</td>
</tr>
<tr>
<td>a) euryhaline mesohalobous taxa with their optimum and tolerance limit within the range of 30-0.2%</td>
</tr>
<tr>
<td>b) α-mesohalobous taxa of the &quot;lower&quot; brackish water, minimum salinity about 10%</td>
</tr>
<tr>
<td>c) β-mesohalobous taxa of the &quot;upper&quot; brackish water, salinity about 10-0.2%</td>
</tr>
<tr>
<td>3. Oligohalobous taxa:</td>
</tr>
<tr>
<td>a) halophilous taxa that can live in both brackish and freshwater; optimum in slightly brackish water</td>
</tr>
<tr>
<td>b) indifferent taxa that can live in both brackish and freshwater; optimum in freshwater</td>
</tr>
<tr>
<td>4. Halophobous taxa: exclusively freshwater taxa</td>
</tr>
</tbody>
</table>

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**FIGURE 3.** Percentage diatom diagram from Hendry Lake.

*Diagramme d'abondance relative des diatomées du lac Hendry.*
FIGURE 4. Percentage diatom diagram from Tasirlaq-sud Lake (lower section).

Diagramme d'abondance relative des diatomées du lac Tasirlaq-sud (partie inférieure).
ISOLATION OF LACUSTRINE BASINS

1) Very fine sandy loam (125-80 cm)

The basal core section in Hendry Lake consists of massive and featureless blue-grey sandy loam which, by its compaction, limited the penetration of the corer. The average grain size distribution within this unit lies between 8 to 17% clay, 18 to 32% silt, and 56 to 74% sand. Loss-on-ignition (LOI) is generally low (1.5-3.5%), with upwards slightly increasing values (Fig. 5). A few mollusc shell fragments were found in this marine unit which was deposited prior to 4300 BP.

2) Loam (80-60 cm)

The sediments within this transitional zone display decreasing grain-size. Sand content (>63 μm) decreases to about 32%. The gradual change from coarser- to finer-grained sediments throughout this zone is paralleled by increases in LOI (3.5-11%) and water content (39-72%) as well as a change in colour to olive-grey (Fig. 5). Both lower and upper boundaries of this unit are smooth. As revealed by the microfossil assemblages (see below), it represents the transition from marine to lacustrine conditions.

3) Fine detritus gyttja (60-0 cm)

This facies consists mainly of olive-grey to olive gyttja representing entirely lacustrine conditions towards the top of the core. In its lower part, the most prominent sedimentary features include several dark laminae that are rich in well-preserved plant macrofossils (moss fragments, conifer leaves). Occurring at irregular intervals between the 60 and 25 cm levels, they represent short-lived perturbations brought about by disturbances in the lake's watershed. The uppermost 25 cm are composed of more homogeneous detrital gyttja. LOI exhibits the highest values (about 20%) between the 50 and 40 cm levels, after which a gradual decrease can be observed. Water content shows more constant values ranging between 72 to 82% (Fig. 5).

TASIRLAQ-SUD LAKE

Three lithostratigraphical units also characterize the lowermost section of this core (Fig. 4):

1) Medium sand (385-373 cm)

Penetration of the Livingstone corer was limited by this lowermost coarse-grained facies. The very low values obtained for both LOI (1.2%) and water content (9-13%) show that it is almost purely inorganic (Fig. 5). The total sand content amounts to approximately 98%. This massive and homogeneous fraction is mainly composed of medium (59%) and coarse sand (20%). This unit had been deposited prior to 4850 BP and probably represents a nearshore sedimentary environment dominated by high-energy, dynamic processes. The boundary with the overlying unit is very sharp.

2) Laminated silt and sand (373-371 cm)

This 2 cm long section consists of fine microlaminae thereby reflecting deposition in a low-energy sedimentary environment, characterized by very stable conditions. Sediments were examined under binocular and SEM microscopes, revealing a total of about 95 discrete laminations averaging 0.2 to 0.3 mm in thickness. The majority of them appear in the form of light/dark couplets resembling varves. It is however not apparent that each couplet represents an annual deposit, as there is no evidence for this apart from their relatively uniform size. Although the laminae can be distinguished clearly by changes in colour and tone, there are only minor differences in texture, showing only a continuous upward fining and decreasing thickness of single laminations. This transitional facies probably represents meromictic conditions as the threshold of the basin prevented the outflow of marine water (Plenitz, 1999).

3) Fine detritus gyttja (371-0 cm)

This lacustrine sediment unit consists of a homogeneous olive-grey to olive gyttja. Both LOI and water content initially show sharp rises between the 371 and 370 cm levels. Thereafter, LOI values demonstrate a more gradual decrease in minerogenic matter and a corresponding, progressive increase in organic matter content from 18 to 38% (Fig. 5). Consequently, the detritus gyttja is relatively compact and gelatinous in its lower part, and becomes increasingly loose and watery towards the surface.

Diatom analysis

All diatom taxa presented in the taxonomic list (see Appendix) are accompanied by autecological information, indicated in conformity with the number code system used by de Wolf (1982). Some modifications were made in accordance with Stabell (1985). For each lake, these data have been used to prepare supplementary diagrams illustrating the ecological preferences of the algae with regard to salinity, pH, and life-form/habitat (Figs. 6 and 7).

Salinity tolerance of the various diatom taxa, as recorded in the Appendix, is based on the redefined halinity determina-

Specification on life-form/habitat and substrate affinity has been obtained mainly from Brockmann (1950), Edsberg (1968), Hendey (1964), Pankow (1976), Van der Werff and Huis (1957-1974), and Vos and de Wolf (1988).

FIGURE 6. Diatom stratigraphy of Hendry Lake in ecological groups.

FIGURE 7. Diatom stratigraphy of Tasiriaq-sud Lake in ecological groups.
The assignment of diatoms to different pH categories was abstracted mainly from Dixit et al. (1988), Foged (1981), Hustedt (1930-1966), Mörriänen (1967), Patrick and Reimer (1966, 1975), and Van der Werff and Huls (1957-1974).

HENDRY LAKE

Diatom zone I (125-80 cm) (Table IV)

The lowest zone diatom zone contains only very few diatom remains (less than $1 \times 10^3$ valves/mg dry weight) so that quantitative analysis was impossible. Differential diatom preservation is indicated since only fragments of the more silicified forms were found, whereas fragments of less silicified, fragile taxa are almost completely absent.

The bulk of these fragments belong to polyhalobous, meioeuryhaline benthic species (e.g. Plagiogramma staurophorum, Rhabdonema arcaatum, R. minutum, Cocconoeis costata, Odontella (Biddulphia) aurita, and Trachyneis aspera) which, according to Simonsen (1962), have salinity preferences between 35 and 17%. The predominance of these benthic forms and the rare occurrence of marine euplanktonic forms, such as Coscinodiscus sp., and Thalassiosira spp., is a clear indication of a shallow nearshore environment.

Meso- and pleoeuryhaline taxa with even higher salinity tolerances (Pinnularia quadrataea; Diploneis smithii) increase towards the upper part of the zone. The increasing number of mesohalobous euryhaline species like Navicula digitoradiata and Scolioleusa tumida (both α-mesohalobous), together with Diploneis interrupta and the more frequently occurring oligohalobous forms, indicate a transition to increasingly brackish water conditions. The strong euryhaline character of the dominant poly- and mesohalobous component suggests that large salinity fluctuations occurred.

The inwash of allochthonous material is indicated by a mixture of marine diatoms with fragments of aereophilic (Pinnularia borealis and P. lata) and freshwater forms (e.g. Tabellaria flocculosa).

Diatom zone II (80-60 cm) (Table IV)

This transitional zone is characterized by marked changes in diatom assemblage composition. The sharp rise in diatom valve concentrations to $5.3 \times 10^6$ valves/mg dry weight at the 65 cm level (Fig. 8) is paralleled by rapid increases in alkaliphilous freshwater taxa, especially the small benthic Fragilariidae spp. (mainly Fragilaria pinnata and Fragilaria construens + F. construens var. venter). This assemblage is accompanied by rare marine forms.

The predominance of Fragilariidae spp. (61-78%) and the general increase in alkaliphilous freshwater taxa (e.g. Achnanthes calcic, Achnanthes cleveti, Navicula jentzschi, Opephora marlyi) indicate strongly alkaline conditions prevailing at the time of sediment deposition. The large centric diatom Melosira teres appears for the first time at the 75 cm level with percentages of about 3 to 5% (Fig. 3).

According to Simonsen (1962), the littoral Fragilariidae spp. are oligohalobous (indifferent) and mesoeuryhaline, which

| TABLE IV |
| Summary of diatom assemblages from pre-isolation and isolation units of Hendry Lake |

Diatom zone I (125-80 cm):
- Substrate property: Very fine sandy loam
- Dominant life-forms: littoral-marine benthic taxa; accompanied by some marine ephiphanic (neritic) forms
- Salinity tolerance range: polyhalobous meio- and pleoeuryhaline; α-mesohalobous

Diatom zone II (80-60 cm):
- Substrate property: Loam
- Dominant life-forms: freshwater benthic taxa; accompanied by some marine benthic + ephiphanic forms
- Salinity tolerance range: oligo- and mesoeuryhaline; β-mesohalobous; halophilous
- Most important species: Achnanthes calcic, A. cleveti, A. delicatula, Anomoeoneis sphaerophora, A. sphaerophora var. scultta, Eilerbeckia teres, Fragilaria brevistriata, F. construens, F. construens var. subsalina, F. construens var. venter, F. fasciculata, F. pinnata, Navicula jentzschi, N. peregrina, Opephora marlyi.

![Tasriaq-sud Lake](Tasriaq-sud Lake.png)

![Hendry Lake](Hendry Lake.png)

**FIGURE 8.** Concentration of diatom valves and percentage of Fragilariidae spp. in lakes Hendry and Tasriaq-sud.

Concentration totale des valves de diatomées et pourcentage de Fragilariidae spp. aux sites Hendry et Tasriaq-sud.

This means that they can tolerate salinities from 0 to about 10%. The simultaneous presence of the halophilous Fragilariidae construens var. subsalina (2.3%) and some mesohalobous forms, such as Achnanthes delicatula, Anomoeoneis sphaerophora var. scultta, Fragilariidae fasciculata and Navicula per-


egrina, reflects slightly brackish water conditions. However, the combined percentages of the halophilous and poly-\(\beta\)-mesohalobous component show a continuous decrease from 7 to 2.8% between the 75 and 65 cm levels, confirming the tendency towards increasingly freshwater conditions (Fig. 6).

Diatom zone III (60-37.5 cm)

The most prominent feature of this diatom zone is the dominance of the large-celled Molosira tores Brun (recently transferred to Eillerbeckia arenaria var. tores (Brun) Crawford). Its relative abundance varies between 43 to 48% and it is accompanied by alkaliphilous freshwater forms (Fig. 3). This species is of special interest in terms of its paleoecologic and paleoclimatic significance because it defines a distinct biozone within this sequence. Its autecology has been discussed in detail in Lortie and Piencit (1988) and Piencit (1969).

The decrease in diatom valve concentration to 2.1-1.7 \(\times\) \(10^4\) valves/mg dry weight is mainly due to the sharp decline in Fragilaria spp. to 46 and 42% at the 55 and 45 cm levels (Fig. 8). Oligohalobous (indifferent) taxa reach their maximum representation of about 96 to 98% whereas poly- and mesohalobous forms almost entirely disappear, thereby clearly indicating freshwater conditions.

Diatom zone IV (37.5-0 cm)

The diatom flora of this uppermost zone is again characterized by the dominance of species of the genus Fragilaria (mostly Fragilaria pinna and F. construens + var. venter). They are accompanied by many other freshwater diatoms, indicating continuous lacustrine conditions until the present-day.

TASIRLAG-SUD LAKE

Diatom zone I (385-373 cm) (Table V)

This diatom zone coincides with the deposition of the basal sand layer. It contains a mixture of brackish and freshwater forms with many marine-brackish species. The latter are typified by littoral benthic taxa having a wide salinity range (e.g. the euryhaline diatoms Amphora crassa, Amphora proteus, Cocconeis pellicoides, Paralia sulcata, and Plagiogramma staurosphorum). Such species are able to withstand large salinity fluctuations, like those occurring in marine littoral zones. Planktonic forms are almost completely absent, except for Paralia sulcata, which is a pleoeyuryhaline marine planktonic form (Simonsen, 1962; Edsbergke, 1968), which sometimes also occurs in the benthic flora (Haggar, 1966).

The quantitatively most important taxon of the polyhalobous component is the littoral-benthic Opephora marina, with percentages of about 10% (Fig. 4). It is a pleoeyuryhaline species common on most coasts (Simonsen, 1962) and has been proposed to be characteristic of the upper sublittoral zone (0.3-1.5 m water depth) on the Swedish west coast (Edsbergke, 1966).

The oligohalobous component makes up about 46 to 49% of the diatom flora (Fig. 7) and is dominated by small Fragilaria spp. (31-37%), whereas the meso- and polyhalobous taxa (40-45%) include the dominant brackish water form Achnanthes delicatula (>19% at the 385 cm level).

The euryhaline Achnanthes delicatula (synonym = A. hauckiana) was found most commonly in slightly to moderately brackish water by Patrick and Reimer (1968), and only within areas influenced by freshwater on the Swedish west coast (Edsbergke, 1966). A mass occurrence of this taxon has been reported by Edsbergke (1968) in the west Norwegian supralittoral zone.

Habitat affinities manifested by the diatom assemblage show close correlation with the nature of the substratum (sand) as indicated by the preponderance of forms living attached to (epipsammic) or between sandgrains (epipellic). Such species are represented by the epipsammic Achnanthes delicatula, Amphora crassa, A. holstica, Cocconeis pellicoides, Navicula cryptolyra, Opephora olseni and Plagiogramma staurosphorum, as well as various epipellic diatoms like Amphora proteus, Diploneis didyma, Navicula cryptolyra, N. digitortadiata, N. forcipata, N. humerosa, N. palpebralis, N. peregrina + var. ketvingensis and N. pygmaea. The strong euryhaline character of this benthic community suggests deposition in a shallow brackish water environment.
Diatom concentrations are low due to the relatively poor preservation and high degree of frustule fragmentation, reflecting conditions of intensive mechanical reworking.

Diatom zone II (373-371 cm) (Table V)

Qualitative diatom analysis was carried out within this microlaminated zone using the tape peel technique developed by Simola (1977).

Pronounced peaks of diatoms occur rather irregularly throughout the short sequence within the light bands of individual couplets or “rhythmites”. In the lower part, they are defined by large numbers of Fragilaria fasciculata and Fragilaria pulchella + var. macrocephala. Both are classified as strongly euryhaline brackish water species. They are accompanied by halophilous forms such as Diatoma elongatum and Fragilaria construens var. subsalina, and a great variety of mesohalobous species commonly occurring in slightly brackish water (e.g. the β-mesohalobous Navicula pygmaea and Anomoeoneis sphaerophora var. sculptra, Navicula rhy- chocephala, N. peregrina + var. kevingensis, N. digitoradi- ata, N. gregaria, N. salinarum, Scoplopleura tunda, and Mastogloia elliptica var. dansei).

In the uppermost part of the laminations, small Fragilaria spp. and Stephanodiscus spp. gain increasing importance. Freshwater species take over while meso- and polyhalobous taxa become increasingly rare.

The frequent occurrence of algal bionts forms, such as Anomoeoneis sphaerophora var. sculptra, Mastogloia elliptica var. dansei, Navicula pygmaea, Rhopalodia gibberula and R. musculus, as well as the strong algal bionts character of the flora, demonstrate conditions of high mineral input in a nutrient-rich environment.

Diatom zone IIa (371-295 cm)

This initial phase of lacustrine sedimentation is characterized by a mass occurrence of benthic algalphids belonging to the Fragilaria spp. group (Figs. 4 and 8). Fragilaria plnatea and F. construens + var. venter are the dominant species in an assemblage almost exclusively composed of oligohalobous (indifferent) and algal bionts forms. The most important taxa, other than the mentioned Fragilaria spp., are Amphora pediculus, Nitzschia fonticola and small Achnanthes spp.

This “peak” or “bloom” represents the greatest relative abundance of Fragilaria spp. (87-95%), as well as the highest values in total diatom concentration (about 7.5 × 10^6 valves/mg dry weight at the 305 cm level: Fig. 8) during the postglacial period.

Diatom zone IIb (295-0 cm)

Benthic algalphids remain the dominant component of diatom assemblages throughout the rest of the core. In general, diatom succession shows a continuous trend from the previous Fragilaria-dominated, “uniform” flora towards a much more diversified, heterogeneous freshwater flora. The floristic changes have been related by Pienitz (1989) to climatic and vegetational shifts.

DISCUSSION

BASAL PRE-ISOLATION UNITS

Hendry Lake

Detailed paleoenvironmental interpretation of changes within the basal inorganic sediments of Hendry Lake is rendered difficult due to certain limitations imposed by preservation and sedimentological factors. However, the extremely low concentrations and poor preservation of diatoms give evidence of disturbances, such as fragmentation, mixing and redeposition. These processes typically occur in unstable, high-energy, nearshore sedimentary environments controlled by tidal dynamics and the scouring action of sea ice. Strong fragmentation of diatom frustules has also been reported frequently in connection with repeated sediment reworking and long-distance transport in coastal environments (e.g. Beyens and Denys, 1982; Lortie in Vincent et al., 1983; Vos and de Wolf, 1988).

Marked floristic heterogeneity is typical of coastal marine environments influenced by high glacial meltwater discharges (Kjerfve, 1981; Lichti-Federovich, 1983). The fossil microflora of the present zone is characterized by a mixed occurrence of polyhalobous and mesohalobous taxa with frequent freshwater forms (especially fragments of aerophilous forms). The dominant component, however, comprises polyhalobous euryhaline forms with the highest species representation in the meioeuryhaline (35 to 17%) salinity range of Simonson’s halinity rating system. These criteria clearly reflect sediment deposition in a nearshore “mixing environment” subject to lowered salinities and extremely large salinity fluctuations, ranging from marine (>30%) to estuarine conditions (ca.18%). The degree of dilution was presumably controlled by large and seasonally varying volumes of meltwater from disintegrating inland ice masses and runoff from deglaciated supra-marine areas.

The geochemical study of stable isotopes (18O/16O ratio) in fossil molluscs suggests similar paleohydrological conditions, with less saline surface waters in littoral zones of D’Iberville Sea and other postglacial seas in Québec (Hillaire-Marcel, 1979). The small quantity of shell fragments within this unit may be related to sediment disturbances caused by the abrasive work and mixing effect of grounding sea ice, which typically occurs in arctic and subarctic marine coastal zones (e.g. Ellis and Wilce, 1961; Hillaire-Marcel, 1979; Gilbert and Aitken, 1981; Aitken and Gilbert, 1986). Besides its erosive effects in macrotidal areas, annual melting and freezing of sea ice largely influences surface water salinities (Ellis and Wilce, 1981; Aitken and Gilbert, 1986).

Stress conditions created by high hydrological instability are expressed by the frequent occurrence of toratological diatoms (= morphological aberrants) in this unit, which is in accordance with observations made on phytoplankton samples from the southern Beaufort Sea (Lichti-Federovich, 1983).

Interpretative difficulties related to the distinction of autochthonous and allochthonous diatoms in “mixed assemblages”, and frustule fragmentation in tidal environments have been
discussed in detail by Vos and de Wolf (1988). In order to reduce this uncertainty as much as possible, a preliminary analysis of other palaeoecological indicators (foraminifera and ostracods) was jointly carried out at two selected levels (125-120 cm and 80-75 cm). Lists of foraminiferal and ostracod species, indicating the relative percentages of the most abundant taxa in each zone, are given in Table VI. According to the results supplied by Guilbault (1988, personal communication), they depict low diversity faunas characterized by euryhaline cold-water forms, such as *Elphidium excavatum*, *Haynesina (Nonion) orbiculare*, *Buccella frigida* and *Cassidulina reniforme*. Similar assemblages have been reported from nearshore (continental shelf) environments in both North America and Europe (reviewed in Guilbault, 1989).

While most of the identified diatom fragments belong to cosmopolitan forms, there are also some species of boreal-arctic affinity and circumpolar distribution indicating cold water conditions. These species include *Cocconeis scutella* var. *stauroniformis*, *Navicula glacialis*, *N. subinflata*, *Grammatophora arctica*, *Rhabdonema arcuatum*, *R. minutum*, *Diploneis rechardtii* var. *tschuktschorum*, *Thalassiosira lacustris* var. *hyperborea*, *Odontella aurita*, and *Diploneis bomboides* var. *media*. Both *Odontella aurita* and *Rhabdonema arcuatum* reach their maximum development at temperatures of about 1°C (Edsosbagge, 1988).

The prevalence of littoral-neritic species and the rarity of euplanktonic forms suggest coastal proximity with depths ranging from shallow subtidal (<15 m) to intertidal conditions. Therefore, a rapidly changing paramarine environment in the form of a shallow embayment seems to have occupied the area (Fig. 9).

**Tasilraq-sud Lake**

The basal minerogenic zone in the Tasilraq-sud Lake core (385-373 cm) differs from that in Hendry Lake with respect to several sedimentary and biological features. The presence of the homogeneous, massive sand layer can be attributed to a sedimentary environment in the upper littoral zone. The distribution of surficial sediments (Fig. 2), as interpreted from aerial photographs, indicates that the basin was at the head of a narrow inlet when sea-level stood at its elevation. The well-sorted sands most likely represent sandflat deposits of a former intertidal zone. They are believed to be underlain by marine clays of the D'Iberville Sea (Pienitz, 1989).

**FIGURE 9.** Series of schematic diagrams illustrating the developmental phases of Hendry Lake during isolation from D'Iberville Sea.

**Succession de diagrammes schématiques illustrant les étapes d'évolution du lac Hendry durant son isolement de la mer d'Iberville.**

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**TABLE VI**

Foraminifera and ostracods in two selected samples from Hendry Lake

<table>
<thead>
<tr>
<th>Sample HEN/125-120 cm</th>
<th>Sample HEN/80-75 cm</th>
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<tr>
<td>Foraminifers:</td>
<td>Foraminifers:</td>
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<tr>
<td><em>Buccella frigida</em></td>
<td><em>Elphidium excavatum</em></td>
</tr>
<tr>
<td><em>Cassidulina reniforme</em></td>
<td><em>Elphidium incertum</em></td>
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<td><em>Miliolinella sp.</em></td>
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<tr>
<td><em>Elphidium albumblicatum</em></td>
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<td><em>Nonion orbiculare</em></td>
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<tr>
<td><em>Elphidium hallandense</em></td>
<td><em>Textularia torquata</em></td>
</tr>
<tr>
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</tr>
<tr>
<td><em>Nonion niveum</em></td>
<td><em>Nonion orbiculare</em></td>
</tr>
<tr>
<td><em>Nonion orbiculare</em></td>
<td><em>Ostracods:</em></td>
</tr>
<tr>
<td><em>Trocchamminia ochracea</em></td>
<td><em>Sarsicytheridea bradyi</em></td>
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<td></td>
<td><em>Sarsicytheridea punctilata</em></td>
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</table>

<table>
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<tr>
<th>MHWL = mean high water level</th>
<th>MLWL = mean low water level</th>
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<td><img src="image" alt="brackish" /></td>
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</tr>
<tr>
<td><img src="image" alt="marine" /></td>
<td><img src="image" alt="loam" /></td>
</tr>
</tbody>
</table>

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Géographie physique et Quaternaire, 45(2), 1991
the eastern coast (Allard et al., 1989). They reflect the decelerating postglacial emergence after 6000 BP.

The autochthonous character of the diatom thanatocoenosis is indicated by the strong "sand affinity" of its dominant epipsammic and epipelagic components. This exactly reflects the textural nature of the substrate. Almost all of the polyhalobous and mesohalobous taxa encountered have extremely wide salinity tolerance ranges (pleoerythraline) and have been previously found closely associated with intertidal sandflats, sandy shoals and beaches (e.g. Brockmann, 1950; Vos and de Wolf, 1988).

Vos and de Wolf (1988) classified diatoms from Holocene coastal deposits of the Netherlands into ecological groups with respect to their salinity tolerances and life-form. Close floristic similarity exists especially between the fossil community of this zone and their Achnanthus delicatula and Amphora proteus ecological groups. These groups comprise epipsammic and epipelagic diatoms that live in sandy sediments of the intertidal zone, or shallow marine basins, which are characterized by salinity ranges of 9 to 30%.

**ISOLATION UNITS**

**Hendry Lake**

The next stage in the development of the lakes was their isolation from the sea (Fig. 9). In Hendry Lake, the exact position of the isolation contact cannot be determined on the basis of lithostratigraphical changes in the sediment column. This is due to a long-lasting, gradual isolation process which may be for the most part explained by the very large tidal range in the region. Considering a hypothetical rate of land uplift of about 5 m/century (see below) and a range of 13 m for large tides, it may have taken 250 to 300 years for the basin to gradually emerge from tidal influence. This tidewater influence would have diminished during the last 50 to 100 years, when the basin was less frequently invaded by large tides and storm surges.

Peculiarities in postglacial marine regression may also have played a role. Lauriol and Gray (1980) reported the presence of intertidal boulder barracades 40 m asl within the neighbouring Rivière aux Feuilles estuarine zone, near Taslijaq. These barracades indicate "a pause in land emergence at the time of deposition". The above-mentioned intertidal flats formerly extended within the Hendry Lake basin and are located at exactly the same altitude. They may relate to these boulder barracades and suggest a corresponding temporary stabilization of relative sea-level.

Moreover, the local topography of the threshold region may have contributed to further protraction of the isolation process, the threshold level being very low and the basin being situated on the interfluve between two major estuaries (Fig. 2). Both the Koksoak and False River estuaries taper off at the latitude of Hendry Lake.

Floristic characteristics support the interpretation of a gradual isolation process; maintenance of slightly brackish conditions is indicated by the continuous representation of poly- and mesohalobous forms in assemblages dominated by freshwater diatoms (especially small Fragilaria spp.). Unstable depositional conditions and mechanical reworking of sediments are reflected in the strongly fragmented diatom frustules and broken sponge spicules.

In general, changes in diatom assemblage composition, total diatom concentration, LOI, and water content are more gradual than in the core from Taslijaq-sud Lake.

**Taslijaq-sud Lake**

The second stage of deposition is represented by the microlaminated zone that abruptly overlies the massive sand layer. The sharp nature of this contact reflects the rapid isolation of this basin.

As a number of studies show, formation and preservation of rhythmically laminated sediments in subarctic and arctic lakes depends on a multitude of interrelated hydrological, depositional and environmental factors (Gilbert et al., 1985; Retelle, 1986; Lemmen et al., 1988). The classic laminations in question appear to be related primarily to seasonally varying influx of allochthonous material, derived from unconsolidated deposits in the lake's catchment. However, annual cycles in sediment deposition ("varved sediments") are not clearly recognizable on the basis of biostratigraphic patterns within the laminations. Variability of sediment inflow on a seasonal scale may have further contributed to the structural complexity of the deposit. Thus, single laminae could represent discrete infill events (climatic or geomorphic events), such as nival floods, storm surges, or other short-lived physical processes.

The presence of seawater trapped in the newly isolated basin is indicated by the important brackish water component of the corresponding fossil microflora. As a result, density stratification may have developed with denser, saline water in the hypolimnion underlying a fresh surface layer continuously replenished by runoff. Density stratification, and subsequent anoxic conditions at depth, appear to be features typical of certain lakes isolated from the sea (e.g. Kjemperud, 1981; Young and King, 1989). The combined effect of this situation with pronounced changes in sediment input, seems to have created favourable conditions for the preservation of sediment laminae.

The initial dominance of brackish epiphytes, such as Cocconeis scutellum, Fragilaria fasciculata, F. pulchella, F. pulchella var. macrocephala, Diatoma elongatum, Rholcosphena curvata, Rhopalodia gibba, R. gibberula, and R. musculus, gives evidence of conditions similar to those prevailing in non-tidal, lagoonal environments. Other species previously reported from brackish lagoons include Hyalidiscus scoticus. With increasing replenishment of the water column from runoff, brackish epiphytes were progressively replaced by freshwater epiphytes having broad salinity tolerances (e.g. Cocconeis placentula, Epithemia sorex, E. turgida, E. zebra, Opephora martiy, Stephanodiscus spp., and species of the genus Fragilaria, especially F. construens var. subalina).

The shift in diatom assemblages from brackish to freshwater epiphytes, and the final takeover of Fragilaria spp.,
clearly reflects decreasing salinities and low-energy lagoonal conditions in a coastal isolation basin.

In the case of Tasirliq-sud Lake, rapid isolation from the sea may have been provoked by fast construction of the beach ridge that presently contains it like a dam. Modern analogs of such gravel and boulder ridges isolating lake basins exist along the shores of the Ungava Bay.

Postglacial Land Emergence of the Kuujjuaq Region

The beginning of lacustrine conditions was dated at 4850 and 4300 years BP in lakes Tasirliq-sud and Hendry, respectively. These dates therefore yield only minimum ages for the isolation from the sea. If marine transgression immediately accompanied deglaciation (Gangloff et al., 1976; Hillaire-Marcel, 1979; Lauriol, 1982; Gray and Lauriol, 1985; Lauriol and Gray, 1987; Allard et al., 1989), the studied lake basins would have been submerged for at least 2500 years. This is only a rough estimate, taking into account that the dated isolation contacts are located 40 to 45 m above present-day sea-level.

Because data associated with deglaciation and maximum marine transgression are almost entirely lacking, only general trends in postglacial land emergence can be traced here. The only data available relate to elevations of the maximum marine limit (MML), which have been determined by air photo interpretation.

According to Lauriol (1982), the 175 m MML isoline for the postglacial D’Iberville Sea passes through Kuujjuaq. Gangloff et al. (1976) indicate an elevation of 183 m asl for the same area. Thus, the mean value of about 180 m asl is considered here as its maximum position. Taking into account that the retreating ice masses were in contact with marine waters, and that the sea stood at its highest relative level at the moment of initial submergence (Hillaire-Marcel, 1979), the MML was presumably reached about 7000 years ago or shortly thereafter. This date represents the extrapolated age of deglaciation of the southern Ungava Bay coastal borderlands, near the mouth of Koksoak River (Lauriol, 1982). It was therefore selected as a reference point for the evaluation of subsequent absolute emergence. The time lag between deglaciation of this site and the Kuujjuaq area, some 50 km upstream, seems to have been insignificant. Rapid retreat of ice masses within the coastal area was favoured by direct cataling of the ice front into the sea, as the Koksoak valley and adjacent lowlands open widely on Ungava Bay (Lauriol, 1982).

Based on these assumptions and the radiometric ages obtained from both isolation contacts, the respective emergence rates for the period prior to basin isolation were determined. The calculated rates are 6.3 cm yr\(^{-1}\) for the period 7000 to 4850 BP in Tasirliq-sud Lake and 5.2 cm yr\(^{-1}\) for the period 7000 to 4300 BP in Hendry Lake. Hence, the postglacial marine level would have stood 125 to 115 m asl at 6000 BP and 75 to 55 m asl at 5000 BP. These values correspond approximately with the 120 to 80 m isobase-range of 6000 BP and the 75 to 50 m isobase-range of 5000 BP that can be inferred for the Kuujjuaq area from isobase maps illustrating postglacial rebound in northern Québec and Labrador (Lauriol, 1982).

Despite all uncertainties arising from the fact that these rates have been determined by approximation, they nevertheless provide a reasonable estimate of local uplift and permit correlation and comparison with other regions along the Ungava Bay coast. Postglacial emergence curves obtained from areas southwest and southeast of the bay show initial uplift rates of about the same magnitude (Fig. 10). In the Rivière Béard Valley near Tasirliq, 120 km west of Kuujjuaq, they reached about 5.6 cm yr\(^{-1}\) between 7000 and 5000 BP, according to the curve constructed by Lauriol (1982). In the George River area to the east, where the marine limit is only 100 m high, Allard et al. (1989) calculated a rate of 4.5 cm yr\(^{-1}\) for the period prior to 5800 BP (Fig. 10).

Based on the dated isolation contacts and known threshold elevations of both lakes, more reliable results can be obtained for the post-isolation period up until present-day. The calculations reveal identical emergence rates of 0.93 cm yr\(^{-1}\) for both sites. This reflects slightly faster land emergence in the Kuujjuaq region than in southeastern Ungava Bay, where Allard et al. (1989) reported a rate of 0.5 cm yr\(^{-1}\) for the period from 5800 BP until present-day. In general, the tentative emergence curve constructed for the Kuujjuaq area (Fig. 10) resembles those curves which present very rapid emergence after deglaciation, followed by a more or less strong inflexion and a subsequent slowing down in isostatic rebound. The rate

**FIGURE 10.** Probable land emergence curve in the Kuujjuaq area in comparison with those of adjacent regions along the Ungava Bay coast.

*Courbe probable de l’émersion des terres à Kuujjuaq en comparaison avec celles de régions voisines, le long de la côte de la baie d’Ungava.*
of change of these curves varies geographically due to proximity to the main load of the Laurentide Ice Sheet.

Differential glacioisostatic recovery occurs mainly in response to previous glacial loading (and related glacioisostatic depression) which explains regionally variable uplift rates (e.g., Hillaire-Marcel, 1979; Gray and Lauriol, 1985). Land emergence rates are the result of a complex interplay between glacial isostasy, glacial eustasy and geoidal eustasy, with changing magnitudes of each component through time (Kjær, 1996). The calculated rates suggest that the coastal lowlands in the vicinity of Kuujjuarapik experienced rapid and progressive land emergence. Because initial rebound was extraordinarily rapid, approximately 76% of total land emergence had occurred by 4600 BP, by which time sea level stood at the present-day (0.93 cm yr⁻¹), which may be the consequence of late ice withdrawal, delayed land uplift, and dominance of the isostatic component through time.

CONCLUSION

The main purpose of this study was to examine the record of Holocene paleoenvironmental changes preserved in the sediments of two coastal basins through an investigation of the diatom spectra. The succession of diatom zones documents changes induced by postglacial isostatic uplift of the Kuujjuarapik region through consecutive periods of marine occupation, isolation from the sea and subsequent lacustrine conditions.

The passage from marine to lacustrine environments appears differently in the two lakes, due to differences in local topography and basin morphology; in Tasiilaq-sud Lake it is reflected in the abrupt change in depositional mechanisms, while the considerable extent of the transitional phase in Hendry Lake indicates a rather gradual and long-lasting isolation process. Reworking of sediments, caused by repeated marine incursions, may have prevented the formation of laminations similar to those preserved in Tasiilaq-sud Lake.

Diatom analysis turned out to be very effective in identifying the position of the isolation contact in the sediment columns and in defining the related changes in paleosalinity. Striking changes in diatom assemblage composition and sharp increases in small *Fragilaria* spp. have been found to be the most prominent features in connection with these marine/lacustrine boundaries.

Threshold height determination, and radiocarbon dating, facilitated a first estimate of regional trends in postglacial land emergence and an approximate reconstruction of uplift rates for an area from which paleogeographical data are almost entirely lacking. No marine transgression was recorded in the cores after 4850 and 4300 BP respectively, thereby suggesting progressive emergence of the coastal lowlands from the sea.

Additional "isolation"-dates from sites located at different altitudes are necessary in order to further define the relative sea-level history of the Kuujjuarapik region and to build a more detailed land emergence curve. This approach could also be more widely used in regions that lack datable raised shorelines and to complement otherwise sparsely dated emergence curves.

ACKNOWLEDGEMENTS

These acknowledgements would be incomplete without expressing our deepest gratitude to the late Dr. Guy Lortie, to whom this paper is dedicated. We wish to extend our appreciation to Drs. M. Ouellet and P. Pagé for assistance in the field, and to Drs. H. Hyvärinen, J. Smol, B. Stabell, and I. Walker for their valuable comments on an earlier version of the manuscript. Dr. J.-P. Guilbault identified the foraminifera and ostracods, which is gratefully acknowledged here. Financial support was provided by the Natural Sciences and Engineering Research Council of Canada, through an operating grant to G. Lortie. This study represents part of the masters thesis of R. Plenitz, whose stay at Université Laval was funded by the student exchange scholarship "Université des Sapparlandes/Université Laval".

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APPENDIX

TAXONOMIC LIST AND AUTOECOLOGY OF DIATOMS FROM LAKES HENDRY AND TASIRLAQ-SUD

S = Salinity (1 = polyhalobous; 2 = mesohalobous; 3 = oligohalobous halophilous; 4 = oligohalobous indifferent; 5 = halophilous)
P = pH (1 = alkalibiontic; 2 = alcaliphilous; 3 = pH-indifferent; 4 = acidiphilous; 5 = acidobiontic)
H = Habitat/Life-form (1 = eulaktonkonic; 2 = tychoplanктic; 3 = periphytic; 4 = aerophilic)

<table>
<thead>
<tr>
<th>Species</th>
<th>S</th>
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<th>H</th>
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<tr>
<td>CAMPYLODISCUS Ehrenberg</td>
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<td>angularis Gregory</td>
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<td>-</td>
<td>3</td>
</tr>
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